8.4 Surface-Water and Sediment Monitoring

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Samples of surface water and sediment on and near the Hanford Site were collected and analyzed to determine the concentrations of radiological and chemical contaminants from Hanford in the aquatic environment. Surface-water bodies monitored included the Columbia River, onsite ponds, and offsite irrigation sources (Figure 8.4.1). Aquatic sediment monitoring was conducted for the Columbia River and one onsite pond. Tables 8.4.1 and 8.4.2 summarize the sampling locations, types, frequencies, and analyses included in surface-water and sediment monitoring during 2004. This section describes the monitoring efforts and summarizes the results for these aquatic environments. Detailed analytical results are reported in PNNL-15222, APP. 1.

8.4.1 Monitoring of Columbia River Water

The Columbia River is the second largest river in the continental United States in terms of total flow and is the dominant surface-water body on the Hanford Site. The original selection of the Hanford Site for plutonium production was based, in part, on the abundant water supply offered by the river. The river flows through the northern portion of the site and forms part of the site's eastern boundary. The river is used as a source of drinking water for onsite facilities and communities located downstream from the Hanford Site. Water from the river immediately downstream of the site also is used for crop irrigation in Benton and Franklin Counties. In addition, the Hanford Reach of the Columbia River is used for a variety of recreational activities, including hunting, fishing, boating, water-skiing, and swimming.

Originating in the Rocky Mountains of eastern British Columbia, the Columbia River and its tributaries drain an area of approximately 670,000 square kilometers (260,000 square miles) en route to the Pacific Ocean. The flow of the river is regulated by three dams in Canada and eleven dams in the United States; four of the dams are downstream of the Hanford Site. Priest Rapids Dam is the nearest upstream dam and McNary Dam is the nearest downstream dam from the site. The Hanford Reach of the Columbia River extends from Priest Rapids Dam downstream to the head of Lake Wallula, created by McNary Dam, near Richland, Washington. The Hanford Reach is the last stretch of the Columbia River in the United States upstream of Bonneville Dam (the first dam upstream from the ocean) that remains unimpounded.

River flow through the Hanford Reach fluctuates significantly and is controlled primarily by operations at upstream dams. Changing river flows result in changes in concentrations of contaminants in river water for users downstream of Hanford (PNL-8531). Annual average flow of the Columbia River downstream of Priest Rapids Dam is approximately 3,400 cubic meters (120,000 cubic feet) per second (WA-94-1). In 2004, the Columbia River had below normal flow; the average daily flow rate downstream of Priest Rapids Dam was 2,830 cubic meters (99,890 cubic feet) per second. The peak monthly average flow rate occurred during June (3,910 cubic meters [138,000 cubic feet] per second) (Figure 8.4.2). The lowest monthly average flow rate occurred during March (2,170 cubic meters [76,700 cubic feet] per second). Daily flow rates varied from 1,380 to 4,840 cubic meters (48,800 to 171,000 cubic feet) per second during 2004. As a result of fluctuation in discharges, the depth of the river varies significantly over time. River stage (water-surface level) may change along the Hanford Reach by up to 3 meters (10 feet) within a few hours (see Section 3.3.7 in PNL-10698). Seasonal changes of approximately the same magnitude are also observed. River-stage fluctuations measured at the 300 Area are approximately half the

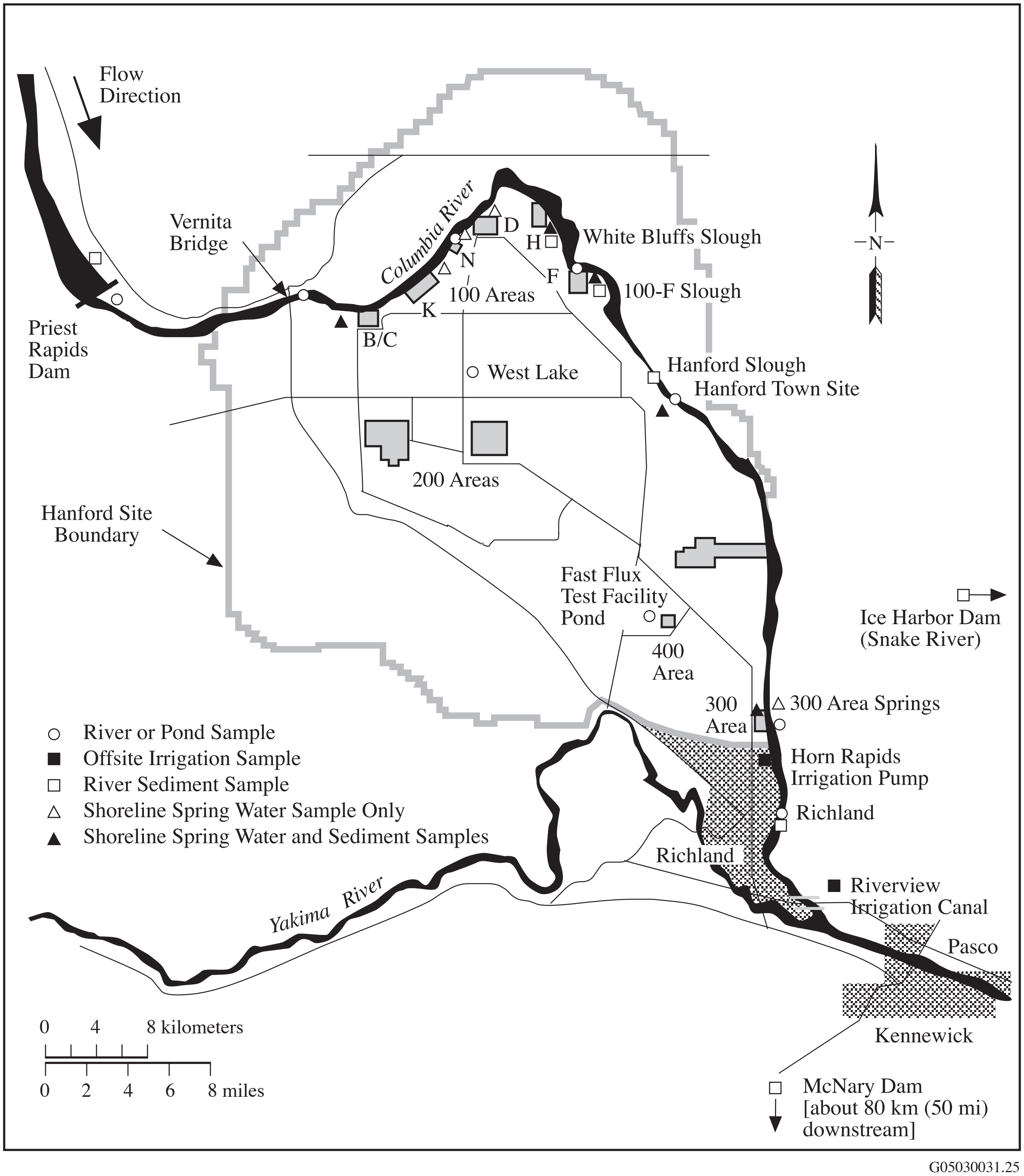

Figure 8.4.1. Surface-Water and Sediment Sampling Locations On and Around the Hanford Site, 2004

Table 8.4.1. Surface-Water Surveillance On and Near the Hanford Site, 2004

Location	Sample Type	Frequency	Analyses
Columbia River - Radiological			
Priest Rapids Dam and Richland	Cumulative	M Comp[a]	Alpha, beta, lo ^{3}H,[b] ^{90}Sr, ^{99}Tc, U[c]
		Q Comp[d]	^{129}I
	Particulate (filter)	M Cont[e]	Gamma energy analysis
		Q Cont[f]	Pu[g]
	Soluble (resin)	M Cont	Gamma energy analysis
		Q Cont	Pu
Vernita Bridge and Richland	Grab (transects)	Quarterly	lo ^{3}H, ^{90}Sr, U
100-F, 100-N, and 300 Areas, and Hanford town site	Grab (transects)	Annually	lo ^{3}H, ^{90}Sr, U
Columbia River - Chemical			
Vernita Bridge and Richland[h]	Grab	3/year	Temperature, dissolved oxygen, turbidity, pH, alkalinity, anions, suspended solids, dissolved solids, specific conductance, hardness (as $CaCO_3$), Ca, P, Cr, Mg, N, Fe, NH_3, NO_3 + NO_2, metals (filtered and
	Grab (transects)	Quarterly	unfiltered), anions
	Grab (transects)	Annually	VOA
100-F, 100-N, and 300 Areas and Hanford town site	Grab (transects)	Annually	Metals (filtered and unfiltered), anions
Onsite Ponds			
West Lake[i]	Grab	Quarterly	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma energy analysis
Fast Flux Test Facility pond	Grab	Quarterly	Alpha, beta, ^{3}H, gamma energy analysis
Offsite Irrigation Water			
Riverview irrigation canal	Grab	3/year	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma energy analysis
Horn Rapids	Grab	Annually	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma energy analysis

(a) M Comp indicates river water was collected hourly and composited monthly for analysis.
(b) lo ^{3}H = Low-level tritium analysis (10-pCi/L detection limit), which includes an electrolytic preconcentration.
(c) U = Isotopic uranium-234, uranium-235, and uranium-238.
(d) Collected hourly and composited for quarterly analysis.
(e) M Cont = River water was sampled for 2 weeks by continuous flow through a filter and resin column and multiple samples were composited monthly for analysis.
(f) Q Cont = River water was sampled for 2 weeks by continuous flow through a filter and resin column and multiple samples were composited quarterly for analysis.
(g) Pu = Isotopic plutonium-238 and plutonium-239/240.
(h) Numerous water quality analyses are performed by the U.S. Geological Survey under contract to Pacific Northwest National Laboratory.
(i) Because of high concentrations of suspended sediment, West Lake water is analyzed for tritium, all other analytes are for sediment samples.
Comp = Composite.
Cont = Continuous.
M = Monthly.
Q = Quarterly.
VOA = Volatile organic compounds.

magnitude of those measured near the 100 Areas because of the effect of the pool behind McNary Dam (PNL-8580) and the relative distance of each area from Priest Rapids Dam. The width of the river varies from approximately 300 to 1,000 meters (980 to 3,300 feet) through the Hanford Site.

Hanford pollutants, both radiological and chemical, enter the Columbia River along the Hanford Reach. Effluent from each direct discharge point is monitored routinely and reported by the responsible operating contractor (Section 8.3). Direct discharges are identified and regulated for non-radiological constituents under the National Pollutant Discharge Elimination System in compliance with the *Clean Water Act* (Section 5.4.1). In addition to permitted direct discharges of liquid effluent from Hanford facilities, contaminants in groundwater from past operational discharges to the ground seep into the river (DOE/RL-92-12; PNL-5289; PNL-7500; WHC-SD-EN-TI-006; Section 8.5 of this report).

Table 8.4.2. Columbia and Snake River Sediment Surveillance, 2004

Location[a]	Frequency	Analyses
Columbia River		River sediment analyses included gamma energy analysis, ^{90}Sr, U[b], Pu[c], metals, SEM/AVS
Priest Rapids Dam: 3 locations near the dam	Annually	
White Bluffs Slough	Annually	
100-F Slough	Annually	
Hanford Slough	Annually	
Richland	Annually	
McNary Dam: 5 locations	Annually	
Snake River		
Ice Harbor Dam: 3 locations near Levy Landing	Annually	

(a) See Figure 8.4.1.
(b) U = Isotopic uranium-234, uranium-235, and uranium-238 analyzed by low-energy photon analysis.
(c) Pu = Isotopic plutonium-238 and plutonium-239/240.
SEM/AVS = Simultaneously extracted metals and acid volatile sulfide.

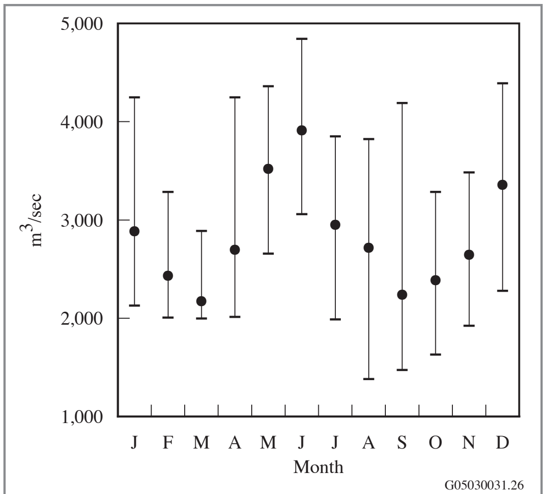

Figure 8.4.2. Mean, Maximum, and Minimum Columbia River Flow Rates at Priest Rapids Dam, Washington, 2004

Washington State has classified the general water use and water quality criteria for the stretch of the Columbia River from Grand Coulee Dam to the Washington-Oregon border, which includes the Hanford Reach, as Class A, Excellent (WAC 173-201A). Water quality criteria and water use guidelines have been established in conjunction with this designation and are provided in Appendix D (Table D.1). In 2003, the Washington State Department of Ecology revised the surface-water quality standards and submitted them to EPA for approval in July 2003 (WAC 173-201A). Under the submitted surface water quality standards, the Class A (Excellent) designated uses criteria will be replaced with separate designations for aquatic life uses, recreational uses, water supply uses, and miscellaneous uses. For the Columbia River downstream from Grand Coulee Dam, the aquatic life designation will be "salmon and trout spawning, noncore rearing, and migration," which provides for the protection of spawning, noncore rearing, and migration of salmon and trout, and other associated aquatic life. The recreational uses designation for the Columbia River downstream from Grand Coulee Dam will be "primary contact," which provides for activities that may involve complete submersion by the participant. The entire Columbia River will be designated for all water supply and miscellaneous uses by the state of Washington.

8.4.1.1 Collection of Columbia River Water Samples and Analytes of Interest

During 2004, Columbia River water samples were collected from fixed-location monitoring stations at Priest Rapids Dam and Richland, Washington, and from cross-river transects and near-shore locations near the Vernita Bridge, 100-N Area, 100-F Area, Hanford town site, 300 Area, and the city of Richland, Washington (Figure 8.4.1). Samples were collected upstream from Hanford Site facilities at Priest Rapids Dam and the Vernita Bridge to provide background data from locations unaffected by site operations. Samples were collected from all other locations to identify any increase in contaminant concentrations attributable to Hanford Site operations, including a municipal drinking water supply and points of withdrawal for irrigation water downstream of the Hanford Site. Sampling of irrigation water systems is discussed in Section 8.4.4.

The fixed-location monitoring stations at Priest Rapids Dam and Richland, Washington, consisted of both an automated sampler and a continuous flow system. Using the automated sampler, unfiltered samples of Columbia River water (cumulative samples) were obtained hourly to collect a composite sample for a period of 7 days. These weekly samples were combined into monthly and quarterly composite samples for radiological analyses (Table 8.4.1). Using the continuous flow system, particulate and soluble constituents in Columbia River water were collected by passing water through a filter and then through a resin column. Filter and resin samples were exchanged approximately every 14 days and were combined into quarterly composite samples for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in detail in DOE/RL-91-50.

Radionuclides of interest were selected for analysis based on the following criteria:

- Their presence in effluent discharged from site facilities or in near-river groundwater underlying the Hanford Site
- Their importance in determining water quality, verifying facility effluent controls and monitoring systems, and determining compliance with applicable water quality standards.

Analytes of interest in river water samples collected at Priest Rapids Dam and Richland, Washington, included gross alpha, gross beta, selected gamma-emitting radionuclides, tritium, strontium-90, technetium-99, iodine-129, uranium-234, uranium-235, uranium-238, plutonium-238, and plutonium-239/240. Gross alpha and beta measurements are indicators of the general radiological quality of the river and provide a timely indication of change. Gamma energy analysis provides the ability to detect numerous specific radionuclides (Appendix F). Analytical detection levels (defined as the laboratory reported minimum detectable concentration) for all radionuclides were less than or equal to 10% of their respective water quality criteria levels (Appendix D, Tables D.1 and D.2). Unless otherwise noted in this section, the statistical tests for differences are paired sample comparisons and two-tailed t-tests, with alpha at 5% significance level.

Transect sampling (multiple samples collected along a line across the Columbia River) was initiated as a result of findings of a special study conducted during 1987 and 1988 (PNL-8531). That study concluded that, under certain flow conditions, contaminants entering the river from the Hanford Site are not completely mixed when sampled at routine monitoring stations located downriver. Incomplete mixing results in a slightly conservative (high) bias in the data generated using the routine, single-point, sampling system at Richland. During 1999, the transect sampling strategy was modified, with some of the mid-river sampling points shifted to near-shore locations in the vicinity of the transect. For example, at the 100-N Area instead of collecting ten evenly spaced cross-river transect samples, only six cross-river samples were collected, and the other four samples were obtained at near-shore locations (typically less than 5 meters [16 feet] from shore). This sampling pattern was used during 2004 and allowed the cross-river concentration profile to be determined and also provided information over a larger portion of the Hanford shoreline where the highest contaminant concentrations would be expected. The Vernita Bridge and Richland transects and near-shore locations were sampled quarterly during 2004. Annual transect and near-shore sampling were conducted at the 100-N and 100-F Areas, Hanford town site, and 300 Area locations in late summer when river flows were low, to provide the highest probability of detecting Hanford contaminants (PNL-8531).

Columbia River transect water samples collected during 2004 were analyzed for both radiological and chemical contaminants (Table 8.4.1). Specific metals and anions were selected for analysis following reviews of existing surface-water and groundwater data, various remedial investigation/feasibility study work plans, and preliminary Hanford Site risk assessments (DOE/RL-92-67; PNL-8073; PNL-8654; PNL-10400; PNL-10535). All radiological and chemical analyses of transect samples were performed on grab samples of unfiltered water, except for metals analyses, which were performed on both filtered and unfiltered samples.

In addition to water quality monitoring conducted by the Pacific Northwest National Laboratory, water quality monitoring was performed by the U.S. Geological Survey for the Pacific Northwest National Laboratory. Samples were collected three times per year along Columbia River transects at the Vernita Bridge and Richland (Appendix C, Table C.6). Sample analyses were performed at the U.S. Geological Survey laboratory in Denver, Colorado, for numerous physical parameters and chemical constituents.

8.4.1.2 Radiological Results for Columbia River Water Sample Analyses

Fixed Location Samples. Results of the radiological analyses of Columbia River water samples collected at Priest Rapids Dam and Richland, Washington, during 2004 are reported in PNNL-15222, APP. 1 and summarized in Appendix C (Tables C.1 and C.2). These tables also list the maximum and average concentrations of selected radionuclides detected in Columbia River water in 2004 and for the previous 5 years. All individual radiological contaminant concentrations measured in Columbia River water during 2004 were less than 1/25 of DOE derived concentration guides (DOE Order 5400.5, Appendix D, Table D.5.) (i.e., DOE derived concentration guides are based on a 100 mrem [1 mSv] per year standard; dividing by 25 allows for more direct comparison of the 4 mrem [0.04 mSv] per year standard used for drinking water), and Washington State ambient surface-water quality criteria (WAC 173-201A and 40 CFR 141; Appendix D, Tables D.2, D.3, and D.5). Significant results are discussed in the following paragraphs, and comparisons to previous years are provided.

Radionuclide concentrations monitored in Columbia River water were low throughout the year. During 2004, tritium, strontium-90, iodine-129, uranium-234, uranium-238, plutonium-239/240, and naturally occurring beryllium-7 and potassium-40 were consistently measured in river water at levels greater than their reported minimum detectable concentrations. The concentrations of all other radionuclides were typically below the minimum detectable concentrations. Tritium, strontium-90, iodine-129, and plutonium-239/240 exist in worldwide fallout from historical nuclear weapons testing as well as in effluent from Hanford Site facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford Site effluent.

The 2004 average gross alpha and gross beta concentrations measured upstream and downstream of the Hanford Site were similar to those observed during recent years (Figures 8.4.3 and 8.4.4). Statistical comparisons for gross alpha and gross beta concentrations at Priest Rapids Dam and Richland were not performed because the majority of the concentrations were below the 1 and 3 pCi/L (0.037 and 0.11 Bq/L) minimum detectable concentrations, respectively. The average gross alpha and gross beta concentrations in Columbia River water at Richland during 2004 were less than the Washington State ambient surface-water quality criteria of 15 and 50 pCi/L (0.56 and 1.9 Bq/L).

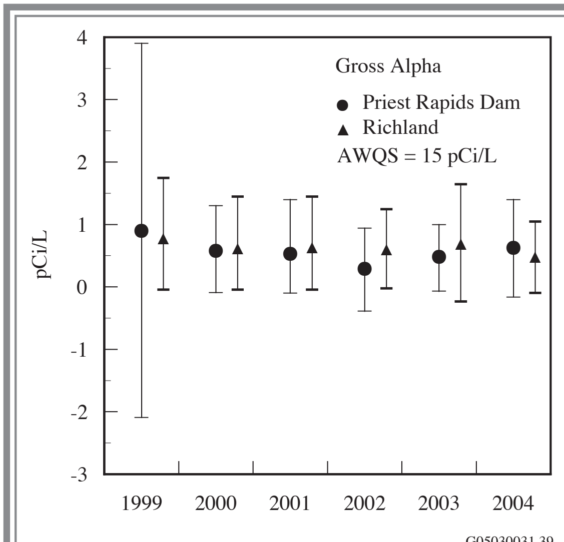

Figure 8.4.3. Annual Average Gross Alpha Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 1999 through 2004 (AWQS = ambient water quality standard)

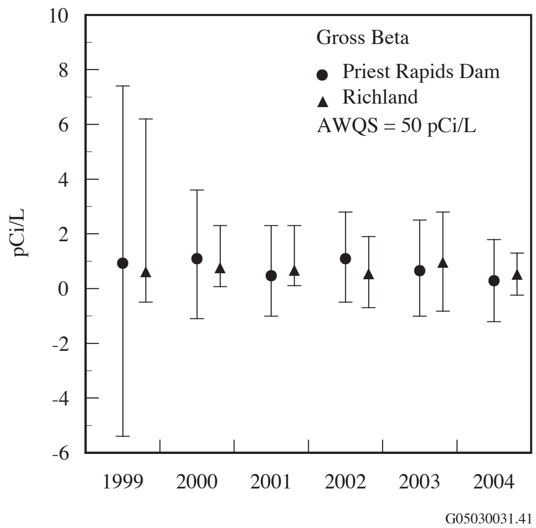

Figure 8.4.4. Annual Average Gross Beta Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 1999 through 2004 (AWQS = ambient water quality standard)

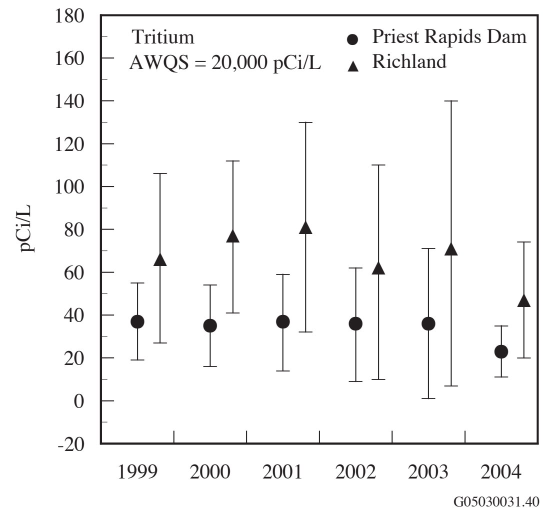

Figure 8.4.5. Annual Average Tritium Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 1999 through 2004 (AWQS = ambient water quality standard)

The 2004 annual average tritium concentrations measured upstream and downstream of the Hanford Site were similar to concentrations measured in recent years. Statistical analyses indicated that monthly tritium concentrations in river water samples at Richland were higher than concentrations in samples from Priest Rapids Dam (Figure 8.4.5). However, 2004 average tritium concentrations in Columbia River water collected at Richland were only 0.24% of the Washington State ambient surface-water quality criterion of 20,000 pCi/L (740 Bq/L). Onsite sources of tritium entering the river included groundwater seepage and direct discharge from the 100-K Area permitted outfall (Section 8.3). Tritium concentrations measured at Richland, while representative of river water used by the city of Richland for drinking water, tend to overestimate the average tritium concentrations across the river at this location (PNL-8531). This bias is attributable to the contaminated 200 Areas' groundwater plume entering the river along the portion of shoreline extending from the Hanford town site to below the 300 Area, which is relatively close to the Richland sample intake. This plume is not completely mixed within the river at Richland. Sampling along cross-river transects at Richland during 2004 confirmed the existence of a concentration gradient in the river under certain flow conditions and is discussed subsequently in this section. The extent to which samples taken at Richland overestimate the average tritium concentrations in the Columbia River at this location is variable and appears to be related to the flow rate of the river just before and during sample collection.

Strontium-90 levels measured in Columbia River water collected upstream and downstream of the Hanford Site during 2004 were similar to those reported previously (Figure 8.4.6). Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Areas. Some of the highest strontium-90 levels that have been found in onsite groundwater are the result of past discharges to the 100-N Area liquid waste disposal facilities. Despite the Hanford Site source, there was no statistical difference between monthly strontium-90 concentrations at Priest Rapids Dam and Richland. Average strontium-90 concentrations in Columbia River water at Richland were less than 0.86% of the Washington State ambient surface-water quality criterion (8 pCi/L [0.30 Bq/L]).

Annual average total uranium concentrations (i.e., the sum of uranium-234, uranium-235, and uranium-238) observed in water samples collected upstream and downstream of the Hanford Site during 2004 were similar to those observed during recent years (Figure 8.4.7). Monthly total uranium concentrations measured at Richland during 2004 were statistically higher (for a one-tailed paired t-test) than

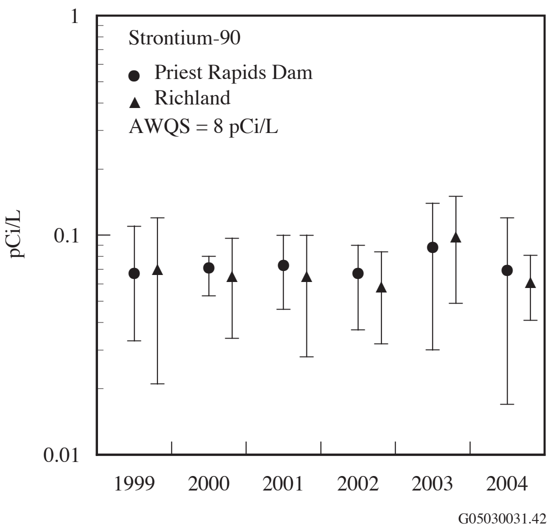

Figure 8.4.6. Annual Average Strontium-90 Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 1999 through 2004 (AWQS = ambient water quality standard)

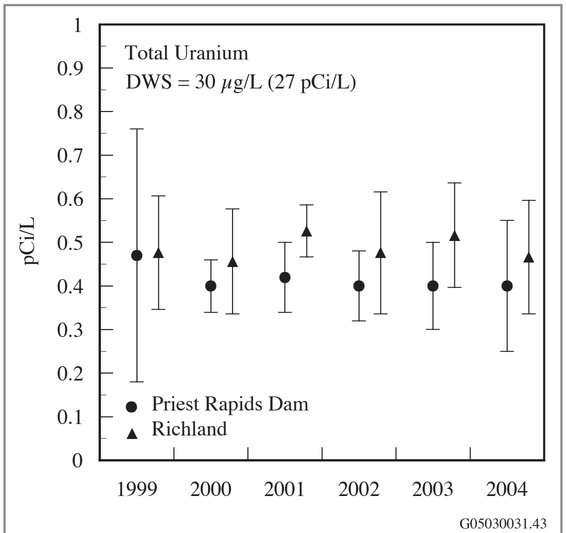

Figure 8.4.7. Annual Average Total Uranium Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 1999 through 2004 (DWS = drinking water standard)

those measured at Priest Rapids Dam. Although there is no direct process discharge of uranium to the river, uranium is present in the groundwater beneath the 300 Area as a result of past Hanford operations. Groundwater contaminants have been detected at elevated levels in riverbank springs at the 300 Area in the past (Section 8.5; PNNL-13692). Uranium is also known to enter the river across from the Hanford Site via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500). There are no Washington State ambient surface-water quality criteria directly applicable to uranium. However, total uranium levels in the river during 2004 were well below the EPA drinking water standard of 30 µg/L (approximately 27 pCi/L [1.0 Bq/L], Appendix D, Table D.2).

The average iodine-129 concentration in Columbia River water measured downstream of the Hanford Site at Richland was extremely low during 2004 (0.007% of the Washington State ambient surface-water quality criterion of 1 pCi/L [0.037 Bq/L]) and similar to levels observed during recent years (Figure 8.4.8). The onsite source of iodine-129 to the Columbia River is the discharge of contaminated groundwater along the portion of shoreline downstream of the Hanford town site. The iodine-129 plume originated in the 200 Areas from past waste disposal practices. Quarterly iodine-129 concentrations in Columbia River water at Richland were statistically higher than those at Priest Rapids Dam indicating a Hanford source of iodine-129. In general, the iodine-129 values at Priest Rapids Dam are largely unaffected by river stage; however, the concentrations measured for river

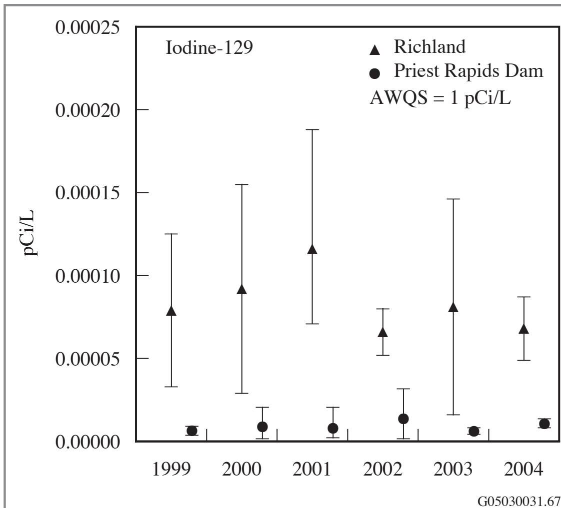

Figure 8.4.8. Annual Average Iodine-129 Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 1999 through 2004 (AWQS = ambient water quality standard)

water at Richland are inversely proportional to river stage (i.e., during lower flow, the concentrations of iodine-129 are higher and vise versa). The influence of river stage on concentrations of iodine-129 at Richland is reflected in the larger standard deviation, compared to the samples from Priest Rapids Dam, for the annual averages shown in Figure 8.4.8.

Plutonium-239/240 concentrations for filtered river water samples at Richland were extremely low during 2004. All plutonium concentrations for both particle and dissolved fractions were reported as undetected by the analytical laboratory, except in one particle fraction sample from Richland (0.000012 ± 0.000010 pCi/L [0.00000044 ± 0.00000037 Bq/L]). The average minimum detectable concentrations were 0.00002 pCi/L (0.00000074 Bq/L) for the particle fraction and 0.00006 pCi/L (0.0000022 Bq/L) for the dissolved fraction. All concentrations and detection limits were well below the DOE derived concentration guide of 30 pCi/L (1.1 Bq/L) (Appendix D, Table D.5). No Washington State ambient surface-water quality criterion exists for plutonium-239/240. Statistical comparisons for dissolved plutonium concentrations at Priest Rapids Dam and Richland were not performed because most of the concentrations were below the reported minimum detectable concentrations.

Columbia River Transect and Near-Shore Samples. Radiological results from samples collected along Columbia River transects and at near-shore locations near the Vernita Bridge, 100-N and 100-F Areas, Hanford town site, 300 Area, and Richland during 2004 are presented in Appendix C (Tables C.3 and C.4) and PNNL-15222, APP. 1. Sampling locations were documented using a global positioning system. Radionuclides consistently measured at concentrations greater than the minimum detectable activity included tritium, strontium-90, uranium-234, and uranium-238. All measured concentrations of these radionuclides were less than applicable Washington State ambient surface-water quality criteria.

Tritium concentrations measured along Columbia River transects during September 2004 are depicted in Figure 8.4.9. The results are displayed such that the observer's

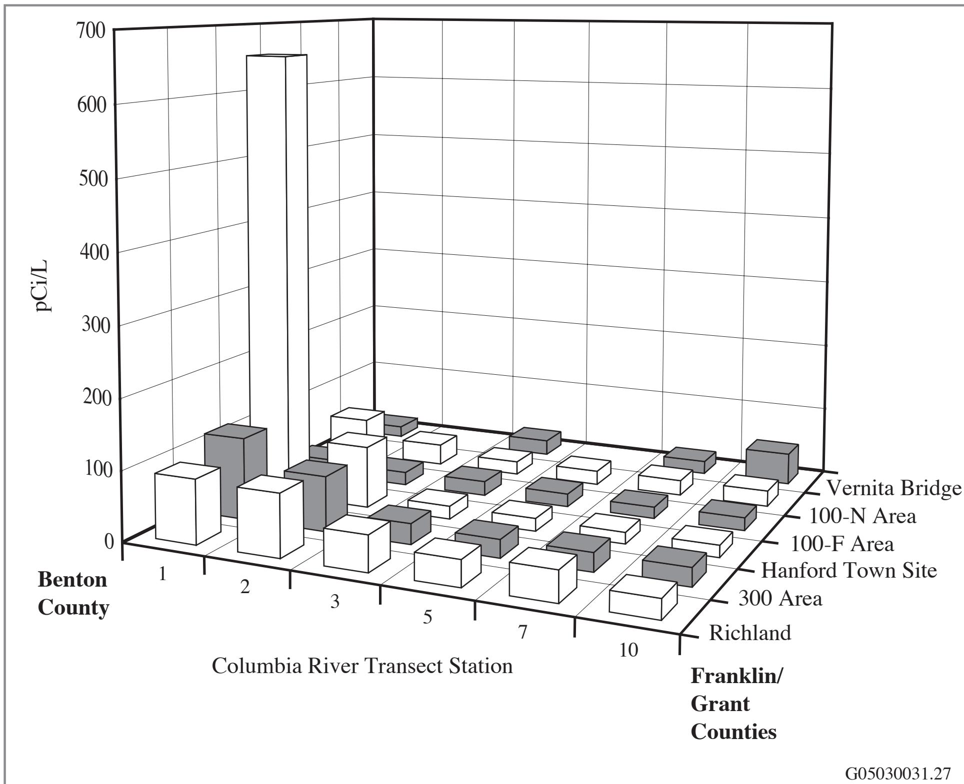

Figure 8.4.9. Tritium Concentrations in Cross-River Transect Water Samples from the Hanford Reach of the Columbia River, September 2004. The ambient water quality standard for tritium is 20,000 pCi/L (740 Bq/L).

view is upstream from Richland. The transect of the Vernita Bridge is the most upstream transect. Stations 1 and 10 are located along the Benton County and Grant/Franklin Counties shorelines, respectively. The 100-N Area, Hanford town site, 300 Area, and Richland transects have higher tritium concentrations near the Hanford (Benton County) shore relative to the opposite shore. The presence of a tritium concentration gradient in the Columbia River at Richland supports previous studies showing that contaminants in the 200 Areas' groundwater plume entering the river at, and upstream of, the 300 Area are not completely mixed at Richland (HW-73672; PNL-8531). The gradient is most pronounced during periods of relatively low river flow. Since transect sampling began during 1987, the average tritium concentration measured along the Richland transect has been less than that measured in monthly composited samples from the fixed-location monitoring station in Richland, illustrating the conservative bias (i.e., overestimate) of the fixed-location monitoring station. For samples collected in 2004, the highest tritium concentration measured in cross-river transect water was 660 ± 56 pCi/L (24 ± 2.1 Bq/L) (Appendix C, Table C.3), which was detected along the shoreline of the Hanford town site. This is a location where groundwater containing tritium at concentrations greater than the Washington State ambient surface-water quality criterion (20,000 pCi/L [740 Bq/L]) is known to discharge to the river (Section 8.7, Figure 8.7.4).

Tritium concentrations for near-shore water samples collected at the Hanford (Benton County) shoreline (typically less than 5 meters [16 feet] from shore) during September 2004 are shown in Figure 8.4.10. The near-shore sampling locations are identified according to Hanford river markers, which are a series of signpost markers, approximately 1.6 kilometers (1 mile) apart, that originate at the Vernita Bridge (Hanford river marker #0) and end

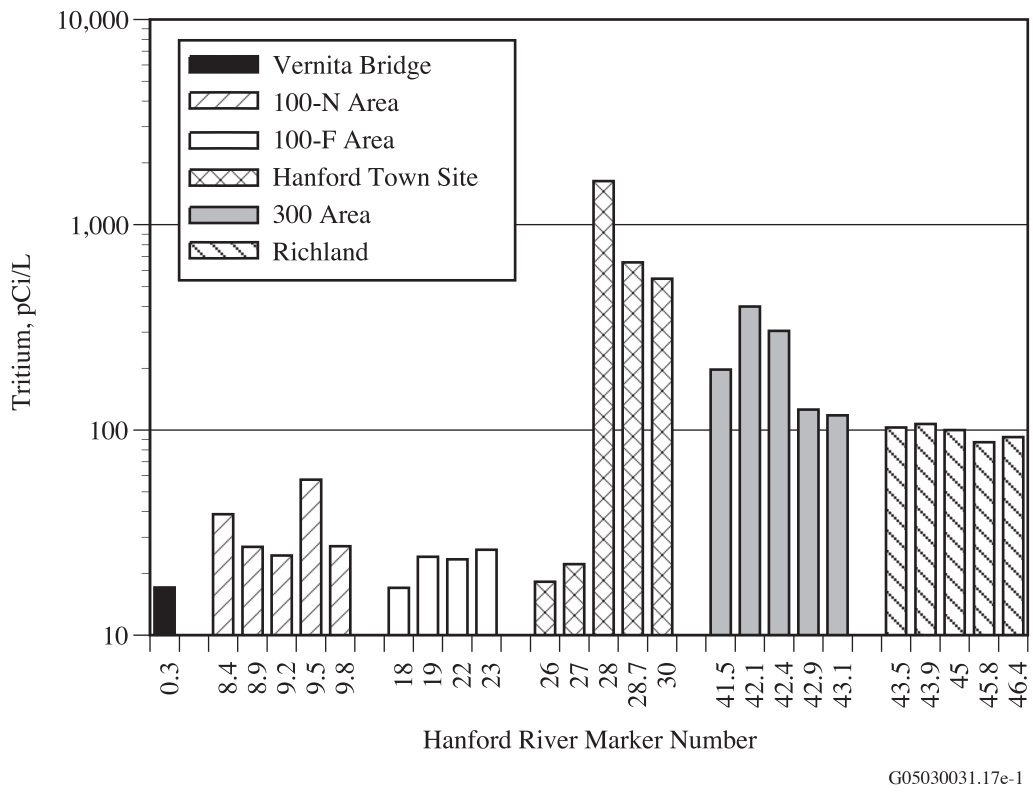

Figure 8.4.10. Tritium Concentrations in Columbia River Water Collected at the Hanford Site Shoreline, 2004. The Hanford river markers (HRMs) are a set of signposts on the Hanford shore that are roughly a mile apart. The Vernita Bridge is HRM #0 and Ferry Street in Richland is HRM #46. Samples collected between markers are assigned a decimal (e.g., halfway between HRM #12 and HRM #13 is HRM #12.5). The ambient water quality standard for tritium is 20,000 pCi/L (740 Bq/L).

at Ferry Street in Richland (Hanford river marker #46). The concentrations of tritium in near-shore water samples collected at the 100-N Area, Hanford town site, 300 Area, and Richland were elevated compared to concentrations in samples collected near the Vernita Bridge. There was a wide range of tritium concentrations measured for the shoreline samples with the concentrations increasing near discharge points for the groundwater tritium plume (Section 8.7, Figure 8.7.4). During 2004, the highest tritium concentration observed in near-shore water samples was 1,600 ± 140 pCi/L (59 ± 5.2 Bq/L) (Appendix C, Table C.4), which was detected along the shoreline of the Hanford town site at Hanford river marker #28. This location is roughly 1 kilometer (0.6 mile) upriver from the cross-river transect sampling location where the maximum tritium level was 660 ± 56 pCi/L (24 ± 2.1 Bq/L).

During 2004, strontium-90 concentrations in Hanford Reach river water for both transect and near-shore samples were similar to background concentrations for all locations, including the 100-N Area where in previous years elevated strontium-90 concentrations were measured in some samples obtained at near-shore locations. The average strontium-90 concentration found during transect sampling at Richland was similar to those measured in monthly composite samples from Richland, indicating that strontium-90 concentrations in water collected from the fixed-location monitoring station are representative of the average strontium-90 concentrations in the river at this location.

Total uranium concentrations in Hanford Reach water during 2004 were elevated along the Benton and Franklin County shorelines for the 300 Area transect. Total uranium concentrations were also elevated along the Franklin County shoreline for the Richland transect. The highest total uranium concentration was measured along the 300 Area transect in September near the Franklin County shoreline (1.8 ± 0.26 pCi/L [0.067 ± 0.0096 Bq/L]) (Appendix C, Table C.3; PNNL-15222, APP. 1) and likely resulted from groundwater seepage and water from irrigation return canals on the Franklin County side of the river that contained naturally occurring uranium (PNL-7500).

8.4.1.3 Chemical and Physical Water Quality Results for Columbia River Water Samples

The Pacific Northwest National Laboratory and the U.S. Geological Survey (under contract to the Pacific Northwest National Laboratory) compiled chemical and physical water quality data for the Columbia River during 2004. A number of the parameters measured have no regulatory limits; however, they are useful as indicators of water quality and contaminants of Hanford origin. Potential sources of pollutants not associated with Hanford include irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500) and industrial, agricultural, and mining effluent introduced upstream from the Hanford Site.

Pacific Northwest National Laboratory Samples. Results of chemical sampling conducted by the Pacific Northwest National Laboratory along transect and near-shore locations of the Columbia River at the Vernita Bridge, 100-F and 100-N Areas, Hanford town site, 300 Area, and Richland are provided in PNNL-15222, APP. 1. The concentrations of metals and anions observed in river water during 2004 were similar to those observed in the past and remain below regulatory limits. Several metals and anions were detected in Columbia River transect samples both upstream and downstream of the Hanford Site. Arsenic, antimony, cadmium, copper, lead, mercury, nickel, and zinc were detected in the majority of samples, with similar levels at most locations. Beryllium, cadmium, chromium, lead, selenium, silver, and thallium were detected occasionally. Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; Appendix D, Table D.3). Increased water hardness (i.e., primarily higher concentrations of calcium and magnesium ions) can reduce the toxicity of some metals by limiting their absorption into aquatic organisms. Criteria for Columbia River water were calculated using a total hardness of 47 mg/L as calcium carbonate, the lowest value based on U.S. Geological Survey monitoring of Columbia River water near the Vernita Bridge and Richland over the past years. The total hardness reported by the U.S. Geological Survey at those locations from 1992 through 2004 ranged from 47 to 77 mg/L as calcium carbonate. All metal and anion concentrations in river water were less than the Washington State ambient surface-water quality criteria for the protection of aquatic life (Appendix C, Table C.5 and Appendix D, Table D.3). Arsenic concentrations exceeded the EPA standard for the protection of human health for the consumption of water and organisms; however, this EPA value is approximately 10,500 times lower than the Washington State chronic toxicity value and similar concentrations were found at the Vernita Bridge and Richland (Appendix D, Table D.3).

For samples collected on the cross-river transects, concentrations of nitrate and sulfate measured near the Hanford shoreline transect samples were elevated at the 300 Area and the Hanford town site. Elevated nitrate concentrations at the Hanford town site shoreline are from the 200 Areas' contaminated groundwater plume, while elevated levels at the 300 Area appear (based on groundwater contaminant contours) to be from agricultural areas to the south. Nitrate concentrations for water samples from the Benton County shoreline near Richland were slightly higher compared to mid-river samples. Chloride, nitrate, and sulfate concentrations were elevated, compared to mid-river samples, along the Franklin County shoreline at Richland and 300 Area transects and likely resulted from groundwater seepage associated with extensive irrigation (the water for which is withdrawn from the Columbia River upstream of the Hanford Site) north and east of the Columbia River. Nitrate contamination of some Franklin County groundwater has been documented by the U.S. Geological Survey (1995) and is associated with high fertilizer and water usage in agricultural areas. Numerous wells in western Franklin County exceed the EPA maximum contaminant level for nitrate (40 CFR 141; U.S. Geological Survey Circular 1144). Average chloride, nitrate, and sulfate results were higher for quarterly concentrations at the Richland transect compared to the Vernita Bridge transect. The concentrations of volatile organic compounds in Columbia River water samples (e.g., chlorinated solvents, and benzene) were below the analytical laboratory's required detection limits for all samples, with no indication of a Hanford source.

U.S. Geological Survey Samples. Figure 8.4.11 illustrates U.S. Geological Survey Columbia River water quality data for samples collected at the Vernita Bridge and Richland for 1999 through 2004 (2004 results are preliminary). Preliminary results for 2004 are also tabulated in PNNL-15222, APP. 1 and summarized in Appendix C (Table C.6). These results are not considered final until they are published by the U.S. Geological Survey (e.g., WA-99-1). The 2004 U.S. Geological Survey results were comparable to those reported during the previous 5 years. Applicable standards for a Class A-designated surface-water body were met. During 2004, there was no indication of any deterioration of water quality resulting from site operations along the Hanford Reach of the Columbia River (Appendix D, Table D.1).

8.4.2 Monitoring of Columbia River Sediment

As a result of past operations at the Hanford Site, radioactive and non-radioactive materials were discharged to the Columbia River. Upon release to the Columbia River, some of these materials were deposited on the riverbed as sediment, particularly in upstream areas near downstream dams. The concentrations of the radioactive materials decreased as they underwent radioactive decay. Fluctuations in the river flow, as a result of the operation of upriver hydroelectric dams, annual spring high river flows, and occasional floods, have resulted in the resuspension, relocation, and subsequent redeposition of the sediment (DOE/RL-91-50). Upper layer sediment in the Columbia River contains low concentrations of radionuclides and metals of Hanford Site origin as well as radionuclides from nuclear weapons testing fallout and metals and other non-radioactive contaminants from mining and agricultural activities (Beasley et al. 1981; BNWL-2305; PNL-8148; PNL-10535; Cox et al. 2004). Periodic sediment sampling is necessary to confirm that concentrations remain low and to assure that no significant changes in concentrations have occurred. The accumulation of radioactive materials in sediment can lead to human exposure by ingestion of aquatic organisms associated with the sediment, sediment resuspension into drinking water supplies, or as an external radiation source irradiating people who are fishing, wading, sunbathing, or participating in other recreational activities associated with the river or shoreline (DOE/EH-0173T).

Since the shutdown of the last single-pass reactor at Hanford during 1971, the contaminant concentrations in Columbia River surface sediment have been decreasing

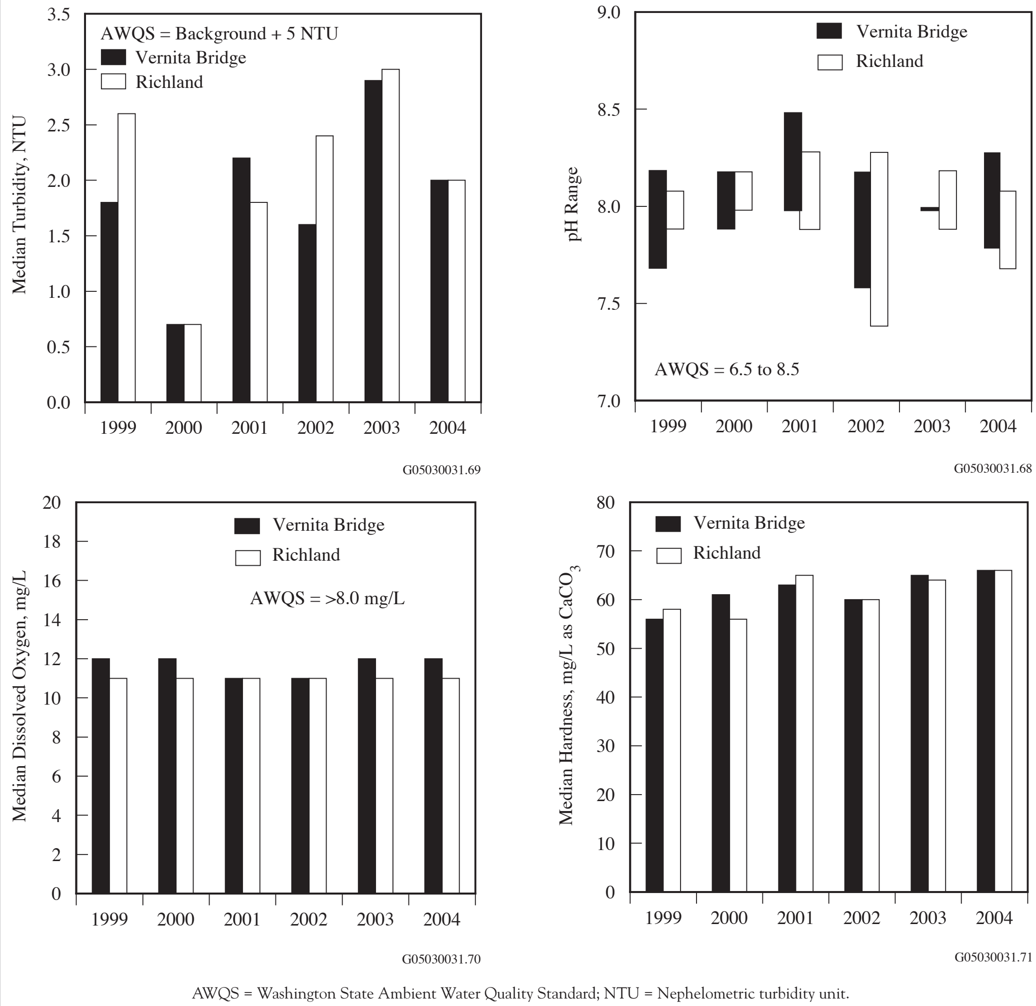

Figure 8.4.11. U.S. Geological Survey Water Quality Measurements for the Columbia River Upstream and Downstream of the Hanford Site, 1999 through 2004 (2004 results are preliminary)

as a result of radioactive decay and the deposition of uncontaminated material on top of the older sediment, which occurs in the reservoirs of the dams located downstream of Hanford (Cushing et al. 1981). However, discharges of some pollutants from the Hanford Site to the Columbia River still occur via permit-regulated liquid effluent discharges at the 100-K Area (Sections 5.4.1 and 8.3) and via contaminated groundwater seepage (Section 8.5).

Several studies have been conducted on the Columbia River to investigate the difference in sediment grain-size composition and total organic carbon content at routine monitoring sites (Beasley et al. 1981; PNL-10535; PNNL-13417). Physical and chemical sediment characteristics were found to be highly variable among monitoring sites along the Columbia River. Samples containing the highest percentage of silts, clays, and total organic carbon were generally collected from reservoirs behind dams located upstream of the site and from White Bluffs Slough on the Hanford Reach.

In 2003 and 2004, the Oregon Department of Energy, Washington State Department of Health, Washington State Department of Ecology, DOE, and Pacific Northwest National Laboratory conducted a multi-agency cooperative study of the four reservoirs (McNary Dam, John Day Dam, The Dalles Dam, and Bonneville Dam) that are downriver from Hanford Site operations (DOH 320-034). Sediment samples and adjacent beach sediment (where available) were collected from each reservoir. Samples were analyzed for radionuclides, chemicals, and physical parameters. In 2003, sediment samples were collected in the reservoir upriver from McNary, John Day, The Dalles, and Bonneville Dams. Beach sediment sampling locations were limited to above McNary Dam and at the mouth of Eagle Creek on the Oregon side of the Bonneville Dam reservoir. In general, the river sediment samples were composed primarily of very fine sand, silt, and clay; the beach sediment was composed primarily of coarse and medium sand. At McNary Dam and The Dalles Dam, there was a trend for coarse-grained sediment on the Washington side of the Columbia River. Total organic content of the river sediment at most locations was above 10,000 mg/kg and the locations with the highest concentrations generally had finer grain sediment. Sediment samples collected in 2003 and analyzed for radionuclides had detectable levels of potassium-40, cobalt-60, strontium-90, cesium-137, europium-152, isotopic uranium, and isotopic plutonium (DOH 320-034). In general, the values were similar to previously reported concentrations at Priest Rapids Dam (Wells 1994; OHD 1994; PNNL-14687). In 2004, the study collected sediment samples at Priest Rapids Dam, McNary Dam, and John Day Dam on the Columbia River and at Ice Harbor Dam on the Snake River. Analytical results and reporting for sediment samples collected in 2004 have not been published at this time.

8.4.2.1 Collection of Columbia River Sediment Samples and Analytes of Interest

During 2004, samples of the surface layer of Columbia River sediment were collected at depths of 0 to 15 centimeters (0 to 6 inches) from six river locations that were permanently submerged (some Hanford Reach sampling locations may not be submerged during extremely low river stage) (Figure 8.4.1 and Table 8.4.2). Sampling locations were documented using a global positioning system.

Samples were collected upstream of Hanford Site facilities from the Priest Rapids Dam reservoir (the nearest upstream impoundment) to provide background data from an area unaffected by site operations. Samples were collected downstream of the Hanford Site above McNary Dam (the nearest downstream impoundment) to identify any increase in contaminant concentrations. Any increases in contaminant concentrations found in sediment above McNary Dam compared to that found above Priest Rapids Dam do not necessarily reflect a Hanford Site source. The confluences of the Columbia River with the Yakima, Snake, and Walla Walla Rivers lie between the Hanford Site and McNary Dam. Several towns, irrigation water returns, and factories in these drainages, as well as atmospheric fallout from weapons testing also may contribute to the contaminant load found in McNary Dam sediment. Thus, sediment samples are periodically taken in the reservoir above Ice Harbor Dam (the first dam on the Snake River upstream of the river mouth) to assess Snake River inputs. Sediment samples also were collected along the Hanford Reach of the Columbia River, from slackwater areas where fine-grained material is known to deposit (e.g., the White Bluffs, 100-F Area, and Hanford Sloughs), and from the publicly accessible Richland shoreline that lies within the influence of the McNary Dam impoundment.

Monitoring sites in the reservoirs behind McNary and Priest Rapids Dams consisted of two stations spaced approximately equidistant on a transect line crossing the Columbia River; the samples were collected near the boat-exclusion buoys immediately upstream of each dam. All other monitoring sites consisted of a single sampling location. Samples were collected using a clam-shell style sediment dredge. The sampling method is discussed in detail in DOE/RL-91-50. All sediment samples were analyzed for gamma-emitting radionuclides (Appendix F), strontium-90, uranium-234, uranium-235, uranium-238, and metals (DOE/RL-91-50). Selected samples were also analyzed for plutonium-238 and plutonium-239/240. The specific analytes selected for sediment samples were based on findings of previous Columbia River sediment investigations, reviews of past and present effluent contaminants discharged from site facilities, and reviews of contaminant concentrations observed in Hanford Site groundwater monitoring wells located near the river.

8.4.2.2 Radiological Results for Columbia River Sediment Sample Analyses

Radionuclides consistently detected in river sediment adjacent to and downstream of the Hanford Site during

2004 included potassium-40, strontium-90, cesium-137, uranium-238, plutonium-238, and plutonium-239/240. The concentrations of all other radionuclides were below the reported minimum detectable concentrations for most samples (PNNL-15222, APP. 1). Cesium-137 and plutonium isotopes exist in worldwide fallout as well as in effluent from Hanford Site facilities. Potassium-40 and uranium occur naturally in the environment, and uranium is also present in Hanford Site effluent. No federal or state freshwater sediment criteria are available to assess the sediment quality of the Columbia River (EPA 822-R-96-001). Radionuclide concentrations reported in river sediment during 2004 were similar to those reported for previous years (Appendix C, Table C.7), and there were no obvious differences between locations. The only unusual value for 2004 sediment samples was for cesium-137 at the White Bluffs Slough, which was roughly 3 times higher than values from the previous 5 years. Median, maximum, and minimum concentrations of selected radionuclides measured in Columbia River sediment (1999 through 2004) are presented in Figure 8.4.12.

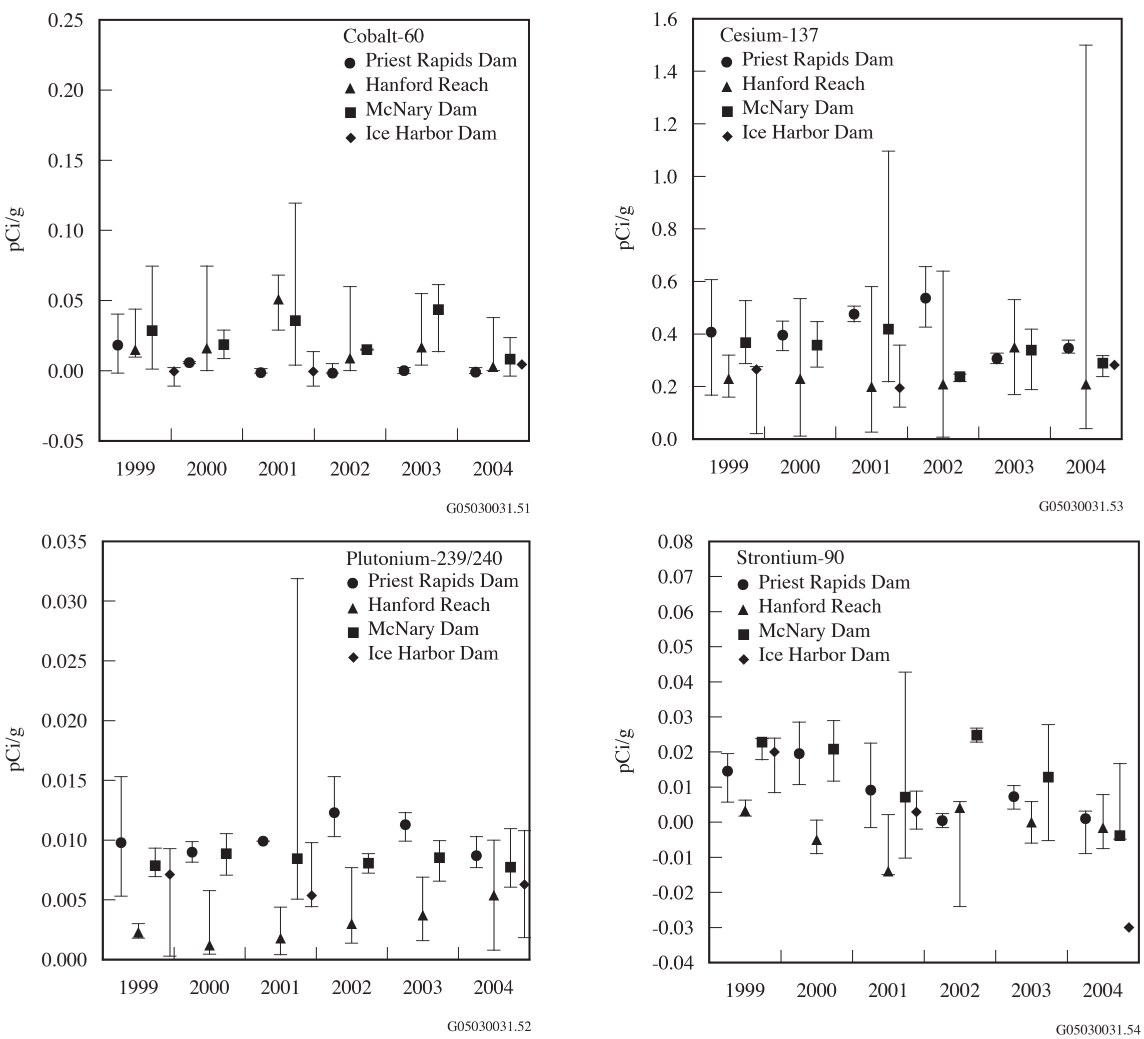

Figure 8.4.12. Median, Maximum, and Minimum Concentrations of Selected Radionuclides Measured in Columbia River (Washington and Oregon) and Snake River (Washington) Sediment, 1999 through 2004. All 2001 through 2004 results for cobalt-60 (except for Hanford Slough, 2003, and White Bluffs Slough, 2004) and 2002 through 2004 results for strontium-90 were below detection limits.

8.4.2.3 Chemical Results for Columbia River Sediment Sample Analyses

Detectable amounts of most metals were found in all river sediment samples (Figure 8.4.13; Appendix C, Table C.8; PNNL-15222, APP. 1). Maximum and median concentrations of most metals were higher for sediment collected in the reservoir upstream of Priest Rapids Dam compared to either Hanford Reach or McNary Dam sediment. The concentrations of cadmium, mercury, and zinc had the largest differences between locations. Currently, there are no Washington State freshwater sediment quality criteria for comparison to the measured values.

Since 1997 (no samples were collected in 2001), Columbia River sediment samples have been analyzed for simultaneously extracted metals/acid volatile sulfide (SEM/AVS). This analysis involves a cold-acid extraction of the sediment followed by analysis for acid volatile sulfide and metals. Acid volatile sulfide is an important binding phase for divalent metals (i.e., metals with a valance state of 2+, such as Pb^{2+}) in sediment. These metals readily bind to sulfides and form metal sulfide precipitates, which are typically very insoluble, and this limits the amount of dissolved metal available in the sediment porewater. The SEM/AVS ratios are an indicator of potential sediment toxicity (DeWitt et al. 1996; Hansen et al. 1996; PNNL-13417). For an individual metal, when the amount of acid volatile sulfide exceeds the amount of the metal (i.e., the SEM/AVS molar ratio is below 1), the dissolved metal concentration in the sediment porewater will be low. For a suite of divalent metals, the sum of the simultaneously extracted metals must be considered, with the assumption that the metal with the lowest solubility will be the first to combine with the acid volatile sulfide.

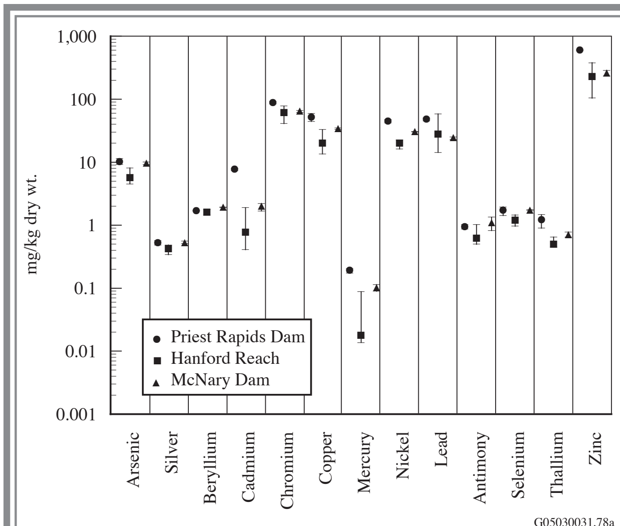

Figure 8.4.13. Median, Maximum, and Minimum Concentrations of Selected Metals Measured in Columbia River Sediment (Washington and Oregon), 2004

The SEM/AVS results for the sediment collected during 2004 from the Priest Rapids Dam and McNary Dam reservoirs were similar to results from previous years (Figure 8.4.14). The average SEM/AVS results for the Hanford Reach sediment collected during 2004 were considerably lower than previous years and were likely influenced by the lower than normal Columbia River flows for 2004, which may have exposed portions of these sediment beds to air. The sediment deposition locations in the Hanford Reach are more subject to annual variations in sediment parameters that can influence SEM/AVS results (e.g., sediment deposition rate, scouring by floods, changes in total organic carbon concentrations, and potential exposure to air during dry periods) than the sediment deposition areas upstream of the dams. During 2004, the acid volatile sulfide values in sediment from the Priest Rapid Dam reservoir had concentrations ranging from 5.0 to 6.7 μmol/g. Sediment from the McNary Dam reservoir had lower concentrations of acid volatile sulfide, with values ranging from 0.97 to 1.8 μmol/g. SEM/AVS molar ratios for sediment from the Priest Rapids Dam reservoir, the Hanford Reach, and McNary Dam reservoir were above 1.0, indicating a potential for some dissolved metals to be present in the sediment porewater. For all locations, zinc was the primary metal present.

Overall results from 1997 through 2004 reveal that acid volatile sulfide concentrations in sediment from the Priest Rapids Dam reservoir are generally higher than concentrations in sediment from the Hanford Reach and the McNary Dam reservoir. An apportionment of acid volatile sulfide by divalent metals according to solubility values revealed that sufficient acid volatile sulfide should exist in all locations to limit the porewater concentrations of cadmium, copper, lead, and mercury. In Priest Rapids Dam sediment, average zinc values were of similar

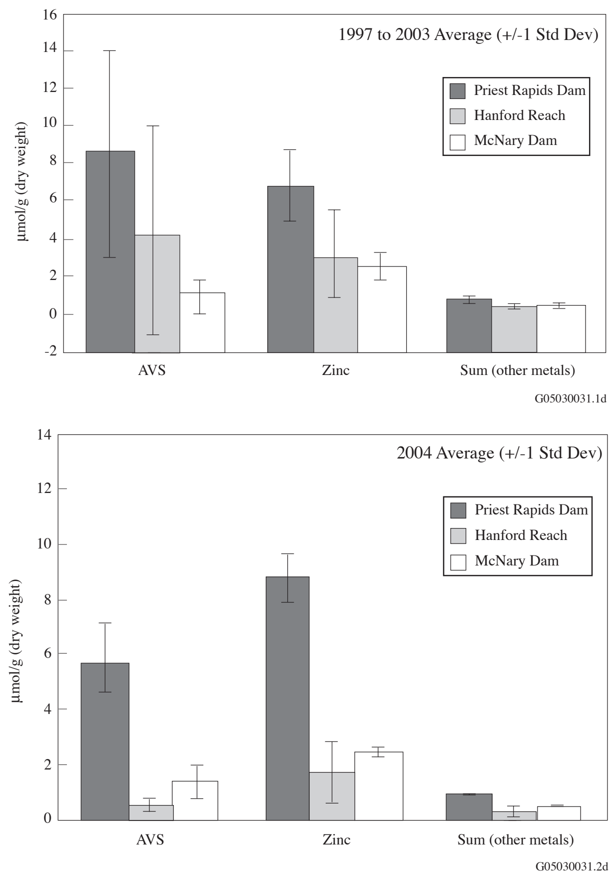

Figure 8.4.14. Average Acid Volatile Sulfide/Simultaneously Extracted Zinc and Sum of Simultaneously Extracted Cadmium, Copper, Lead, Nickel, and Mercury in Columbia River Sediment, 1997 through 2003 Compared to 2004 Data

magnitude as the average acid volatile sulfide concentrations. In McNary Dam sediment, the average zinc concentrations were higher than the available mean acid volatile sulfide pool, indicating the potential for zinc and possibly other dissolved metals to be present in the sediment porewater.

8.4.3 Monitoring of Onsite Pond Water and Sediment

Two onsite ponds, West Lake and the Fast Flux Test Facility pond (Figure 8.4.1), located near facilities in various stages of remediation, were sampled periodically during 2004. The ponds were inaccessible to the public and, therefore, did not constitute a direct offsite environmental impact during 2004. However, they were accessible to migratory waterfowl and deer, creating a potential biological pathway for the dispersion of contaminants (PNL-10174). The Fast Flux Test Facility pond is a disposal site for process water, primarily cooling water drawn from groundwater wells. West Lake, the only naturally occurring pond on the site, is located north of the 200-East Area (ARH-CD-775). West Lake has not received direct effluent discharges from Hanford Site facilities but it is influenced by changing water-table elevations that are related to the discharge of water to the ground in the 200 Areas. The water level in West Lake fluctuates and changes from standing water in winter and spring to nearly dry in summer and fall.

8.4.3.1 Collection of Pond Water and Sediment Samples and Analytes of Interest

During 2004, grab samples were collected quarterly from the Fast Flux Test Facility pond (water) and from West Lake (water and sediment). All water samples were analyzed for tritium. Water samples from the Fast Flux Test Facility pond were also analyzed for gross alpha and gross beta concentrations as well as gamma-emitting radionuclides. The groundwater table in the 200-East Area has dropped in recent years (Section 8.7) and this has decreased the size of West Lake and caused the suspended sediment loading to increase. Starting in 2002, it has not been practical for the analytical laboratory to process West Lake water samples for gross alpha, gross beta, strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238 because of the high sediment load; thus, sediment samples were submitted for these analytes. Constituents were chosen for analysis based on their known presence in local groundwater and their potential to contribute to the overall radiation dose to biota that frequent the ponds.

8.4.3.2 Radiological Results for Pond Water and Sediment Sample Analyses

All radionuclide concentrations in onsite pond water samples were less than applicable DOE derived concentration guides (DOE Order 5400.5; Appendix D, Table D.5) and Washington State ambient surface-water quality criteria (WAC 173-201A; 40 CFR 141; PNNL-15222, APP. 1; Appendix D, Tables D.1 and D.2).

Figure 8.4.15 shows the annual gross beta and tritium concentrations in Fast Flux Test Facility pond water from 1999 through 2004. Median levels of both constituents have remained stable in recent years. The median tritium concentration in Fast Flux Test Facility pond water during 2004 was 14% of the Washington State ambient surface-water quality criterion of 20,000 pCi/L (740 Bq/L). The sources of contaminants in the pond water are groundwater contaminant plumes from the 200 Areas that have migrated to wells near the Fast Flux Test Facility that supply water to facility operations.

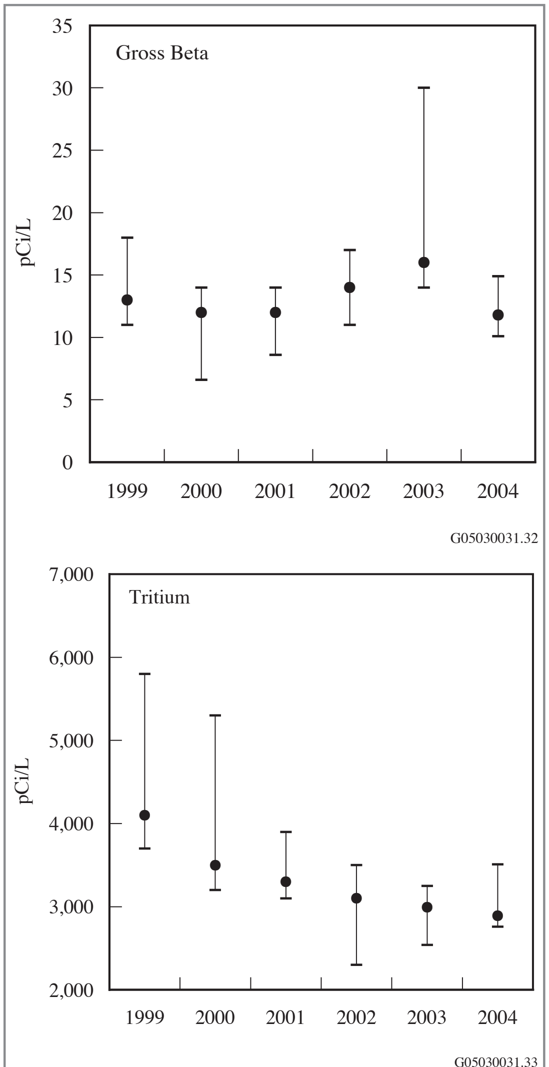

Figure 8.4.15. Median, Maximum, and Minimum Gross Beta and Tritium Concentrations in Water Samples from the Fast Flux Test Facility Pond on the Hanford Site, 1999 through 2004

Tritium concentrations in West Lake water during 2004 were similar to those observed in the past (Figure 8.4.16). The median concentration of tritium in West Lake water in 2004 was 0.9% of the Washington State ambient surface-water quality criterion level (20,000 pCi/L [740 Bq/L]) and reflected groundwater concentrations in the area.

Samples of West Lake sediment in 2004 had the following range of detectable values:

- gross alpha – 3.3 to 12 pCi/g (0.12 to 0.44 Bq/g)
- gross beta – 22 to 26 pCi/g (0.81 to 0.96 Bq/g)
- potassium-40 – 14 to 21 pCi/g (0.52 to 0.78 Bq/g)
- strontium-90 – 0.11 to 0.60 pCi/g (0.0041 to 0.022 Bq/g)
- cesium-137 – 0.49 to 1.8 pCi/g (0.018 to 0.067 Bq/g)
- uranium-234 – 0.38 to 4.8 pCi/g (0.014 to 0.18 Bq/g)
- uranium-235 – 0.011 to 0.17 pCi/g (0.00041 to 0.0063 Bq/g)
- uranium-238 – 0.34 to 4.4 pCi/g (0.013 to 0.16 Bq/g).

These levels of radionuclides are similar to previous measurements (PNL-7662). Uranium concentrations are believed to result from naturally occurring uranium in the surrounding soil (BNWL-1979).

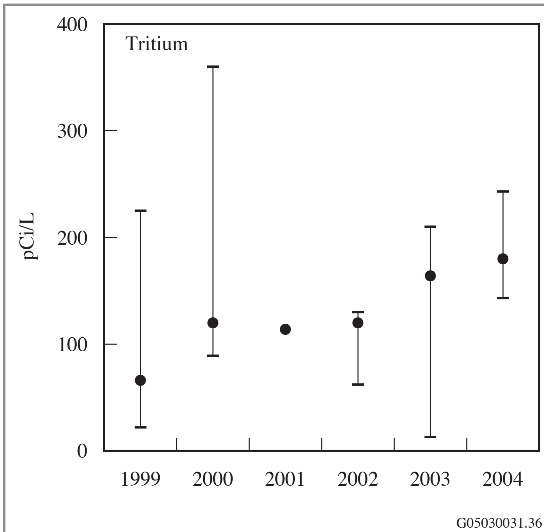

Figure 8.4.16. Median, Maximum, and Minimum Concentrations of Tritium in Water Samples from West Lake on the Hanford Site, 1999 through 2004

8.4.4 Monitoring of Offsite Irrigation Water

During 2004, water samples were collected from an irrigation canal located across the Columbia River and downstream from the Hanford Site at Riverview and from an irrigation water supply on the Benton County shoreline near the southern boundary of the Hanford Site (Horn Rapids irrigation pumping station) (Figure 8.4.1). As a result of public concerns about the potential for Hanford-associated contaminants in offsite water, sampling was conducted to document the levels of radionuclides in water used by the public. Consumption of vegetation irrigated with Columbia River water downstream of the site has been identified as one of the primary pathways contributing to the potential dose to the hypothetical maximally exposed individual and any other member of the public (Section 8.14).

Collection, Analysis, and Results for Offsite Irrigation Water Samples

Water from the Riverview irrigation canal and the Horn Rapids irrigation pumping station was sampled three times during the 2004 irrigation season. Unfiltered samples were analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, uranium-234, uranium-235, and uranium-238. During 2004, radionuclide concentrations measured in irrigation water were at the same levels detected in the Columbia River (PNNL-15222, APP. 1). All radionuclide concentrations were below their respective DOE derived concentration guides and Washington State ambient surface-water quality criteria (DOE Order 5400.5; WAC 173-201A; 40 CFR 141).